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Evaluating P and K Fertilizer Prescriptions from Site-Specific Technologies

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Developing a field's fertilizer prescription as a part of a site-specific nutrient management plan can be one of the more costly tasks undertaken. Those costs are traditionally associated with gathering of a number of plant and/or soil samples, their testing, as well as acquiring and applying amendments. Soil sample analysis is particularly important for traditional phosphorus (P), potassium (K) and soil acidity (pH) management. Soil sampling requires skill and time, time that may be in short supply when crop harvest is to be soon followed by establishment of a succeeding crop. Soil test results are not always timely, further delaying nutrient management plan development. Due to the expense, grid soil sampling is often only done every 3 to 5 years, which raises the question of how much fertilizer is to be applied between soil sampling events. Other site-specific technologies, especially the yield maps generated with spatially referenced yield monitoring, have been proposed to resolve these problems.

Fertilizer prescription maps based on nutrient removal can be developed directly from a field's yield map by multiplying yield by the grain P or K concentration, taken from published tables. Intuitively, nutrients would be applied to replace nutrients removed by the previous crop. A random sample of the grain could be analyzed if values from published tables were thought inappropriate.

There are potential problems to this approach. Limiting factors other than nutrient stress often cause yield differences within the field. Should this year's weed competition pattern drive fertilizer application for the next crop? If, for example, a low level of available soil P is limiting crop yield in part of the field, should that area continue to be fertilized according to the low P removal of the P deficient crop? New technologies like the yield monitor and spatial analysis may help improve fertilizer prescriptions, but how do they compare with the existing options?

Methodology

In this work, we compared four approaches for generating fertilizer rate prescriptions for P. These approaches were: a) our "expensive standard", based on grid soil sampling the field (approx. 1 sample/0.83 acre) and spatial analysis of the soil test results; b) based on the average soil test value from all the grid soil samples taken in the field; c) based on the field's yield map, values for grain P taken from a published table, and spatial analysis of calculated nutrient removal; and d) based on the field's yield map, values for grain P determined on a single composite sample of grain taken from the field, and spatial analysis of calculated nutrient removal.

We selected two producer fields in Marion County, designated 112 (51.4 ac) and 950 (43.4 ac), to compare these approaches to fertilizer P prescriptions. In both fields, the dominant soil is well-drained Crider silt loam, but they also contain significant areas of only moderately well drained soil (Lowell, Nicholson or Tilsit silt loams). Field 112 had a history of chemical fertilizer applications and 950 had a history of swine manure and fertilizer N applications. Corn yield was determined with a calibrated yield monitor on a GPS equipped combine. Grain and soil samples were taken just before harvest at the same point, on a 180 x 200 ft grid, (Figure 1A). A digital elevation map was determined for each field. Soil test P was determined by the Mehlich III extraction procedure at the University of Kentucky's Division of Regulatory Services soil test laboratory. This lab also determined soil pH and organic matter on each soil sample. Grain tissue was analyzed for P by the University of Kentucky Plant and Soil Sciences Department's Analytical Services Laboratory.

Geostatistics was used to characterize spatial variation in crop yield/nutrient removal and soil properties within each field. The tabular value used to calculate nutrient removal maps was 0.326 % P = 0.353 lb P2O5/bu . Table 1 shows the fertilizer rate prescription as related to P removal or to soil test P values.

Results

"Composite" soil test, grain yield and grain tissue P information for the two fields are given in Table 2. On average, field 950 was higher than field 112 in soil test P and organic matter, but pH was similar. Grain yield was lower, and more variable, in 112 than 950. For 950, grain P was close to the tabular value, and grain from 112 was lower than the tabular value.

Figures 1a and 1b show locations of sample points, elevation, and yield (interpolated) in 950. We observed, in general, that lower elevation and decreased soil drainage capacity were associated with lower corn yields. Considerable variation in soil test P within 950 is shown in Figure 2a, but no fertilizer P would be recommended for the grid or composite soil test methods because there were no areas with a soil test P value below 60 lb/acre. The nutrient removal/fertilizer prescription map for 950, using the yield map and the tabular grain P concentration (Fig. 2b) delimits two areas, with rate prescription differences mostly due to large yield differences. The nutrient removal based fertilizer prescription map obtained using the "composite" of grain P values actually measured in that field was very similar to that found using the tabular grain P value. Comparing the four methods of arriving at a P prescription for 950, the nutrient removal/fertilizer prescriptions always called for more fertilizer than the soil test prescriptions on this manured field (Table 3). Areas in the removal maps calling for a greater fertilizer P rate were often those areas with higher soil test P (Fig.2).

The soil test P map for field 112 (not shown) also showed considerable variation. Comparing prescription approaches for this field, fertilizer P is over prescribed, relative to that recommended by grid soil sampling, by the two nutrient removal approaches (Table 4). In this field, the greater difference between the grain P concentration value for grain taken from the field and the value taken from the table caused the fertilizer P prescriptions to differ. The "composite" soil analysis recommended a uniform rate of 30 lb P2O5 per acre for this field. Relative to grid soil sampling, the uniform P rate prescription was appropriate for a third of the field, over-fertilized a third of the field, and under-fertilized a third of the field.

Conclusions

Composite soil sampling was not always inferior to grid soil sampling in terms of the resulting fertilizer P or K prescriptions, especially when both approaches confirmed that no fertilizer was needed. In general, using yield-nutrient removal maps to derive fertilizer prescription maps resulted in greater P and K prescriptions than either soil test approach. We also observed that as the tabular grain P concentration value deviated from the P concentration taken from a field's grain samples, there were greater differences in the nutrient removal fertilizer P prescription map. Our results suggest that using spatially referenced yield information and tabular grain concentration information to develop fertilizer P and K rate prescription maps rests upon assumptions that were often not valid. These problematic assumptions include: a) that the field's grain composition is generally uniform and close to that given in the chosen table; and b) that P and K removal by the past crop, rather than the current P and K soil test values, are better related to the need for fertilizer P and K for the next crop. We speculate that the yield map might be used to stratify a field into more uniform "management zones", which would then be randomly soil sampled for optimal nutrient management information. We are presently evaluating this option.

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Table 1. Fertilizer prescriptions as related to removal or soil test values.

Fertilizer Prescription ($lb\ P_2O_5/ac$)	**Removal (lb/ac) ($lb\ P_2O_5/ac$)**	**Soil Test P (lb/ac)**
0	0-15	> 60
30	15-45	42-60
60	45-75	28-42
90	75-105	14-28
120	105-135	0-14

Table 2. Soil test, yield, and grain composition information for each field (mean ± one standard deviation).

Property	Field 950	Field 112
Soil Test P (lb/ac)	147 ± 64	54 ± 31
OM (%)	3.3 ± 0.6	2.6 ± 0.4
pH	6.4 ± 0.3	6.3 ± 0.6
Yield (bu/ac)	138 ± 22	130 ± 47
Grain P (%)	0.35 ± 0.03	0.29 ± 0.04

Table 3. Portion (in %) of field 950 receiving each fertilizer P rate, according to the prescription method.

Fertilizer Prescription (lb P_2O_5/ac)	Grid Soil Test P (%)	Composite Soil Test P (%)	Removal Tabular Grain P (%)	Removal Composite Grain P (%)
0	100	100	0	0
30	0	0	38.4	23.3
60	0	0	61.7	76.7
90	0	0	0	0
120	0	0	0	0

Table 4. Portion (in %) of field 112 receiving each fertilizer P rate, according to the prescription method.

Fertilizer Prescription (lb P_2O_5/ac)	Grid Soil Test P (%)	Composite Soil Test P (%)	Removal Tabular Grain P (%)	Removal Composite Grain P (%)
0	30.5	0	0	0
30	36.0	100	43.1	74.1
60	31.7	0	56.5	25.9
90	1.7	0	0.5	0
120	0	0	0	0

Figure 1. - Field 950 A) Elevation and sampling points; B) Interpolated yield map.

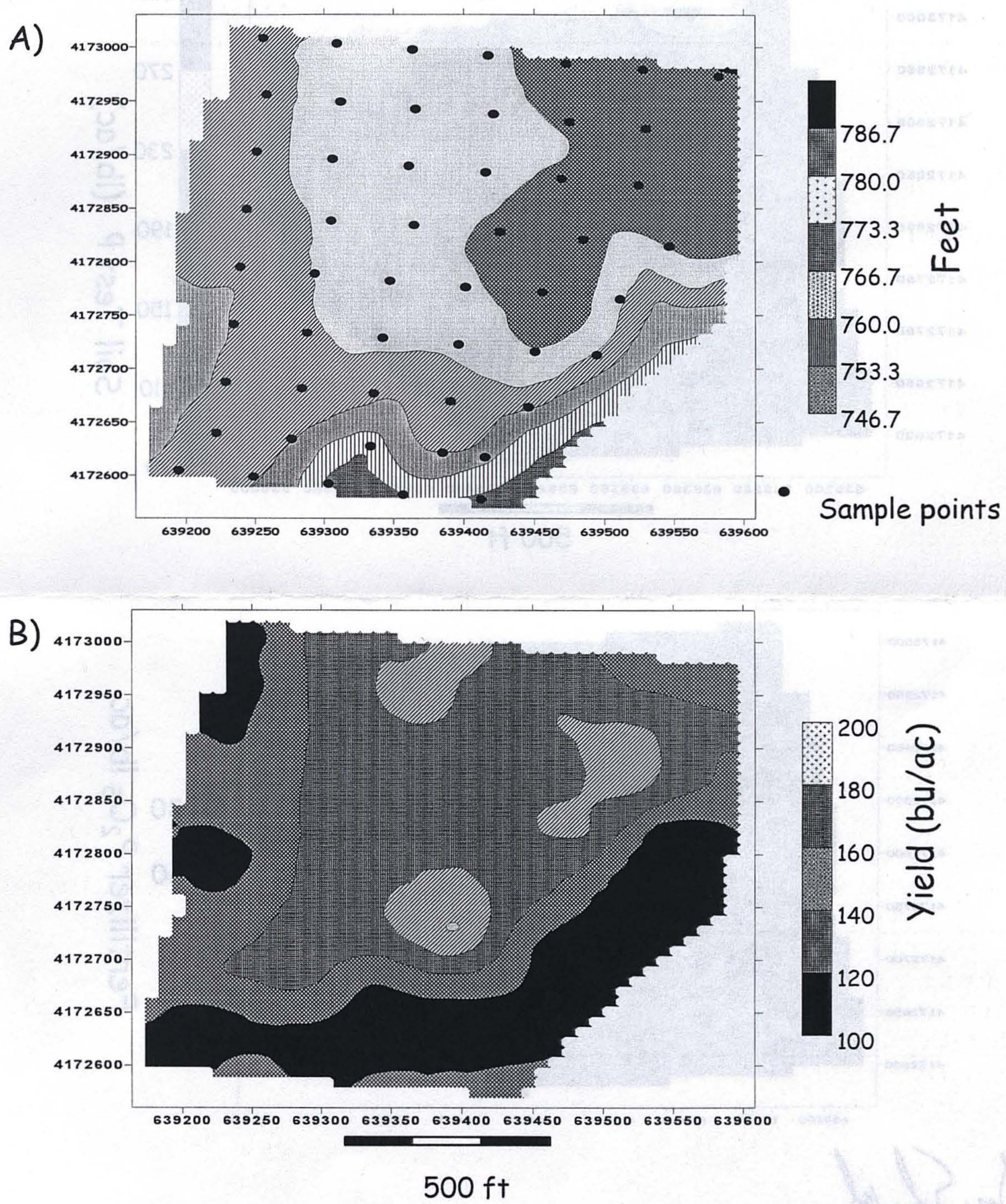
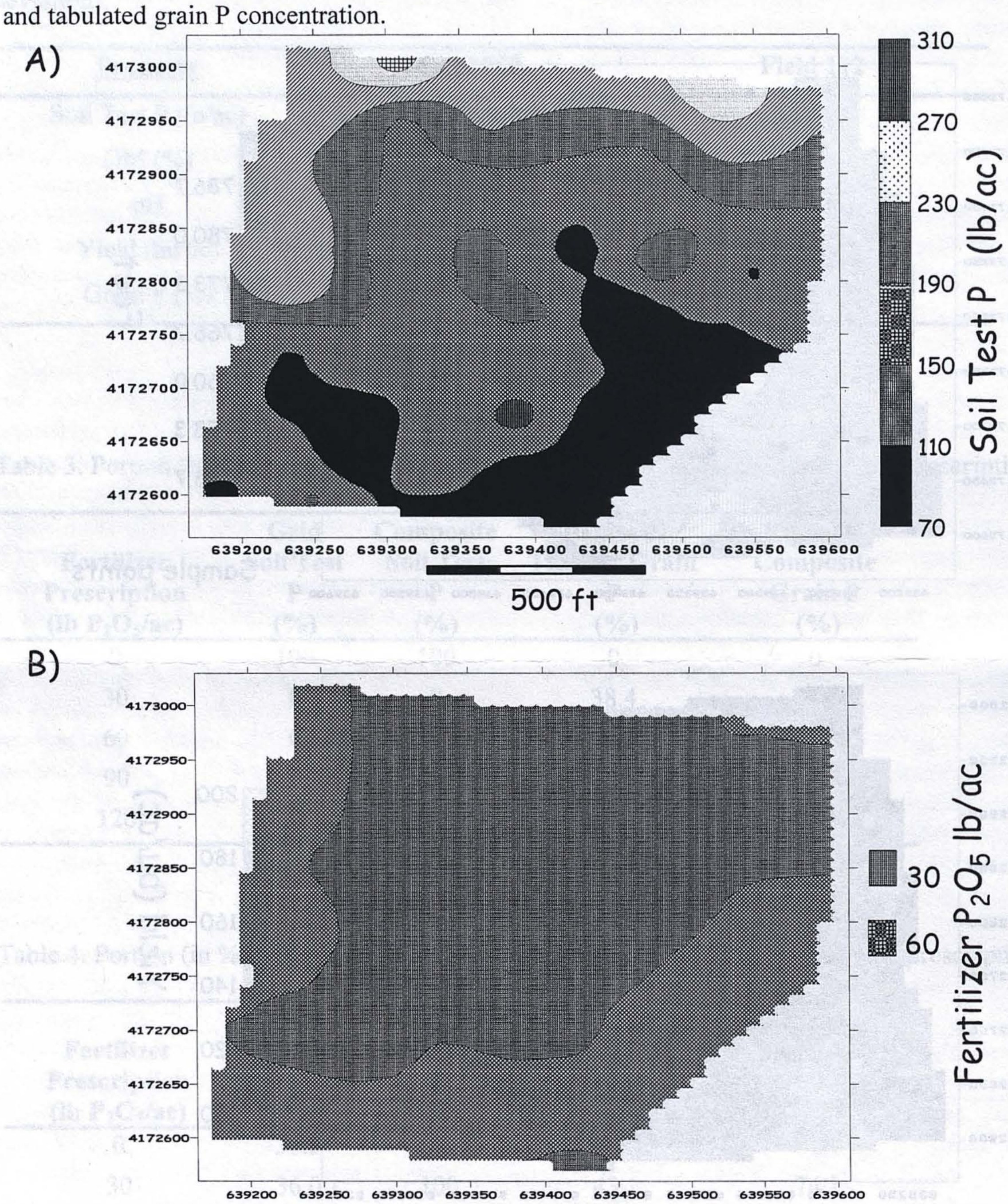


Figure 2. - Field 950 A) Map of soil test P; B) Fertilizer P prescription from P removal using yield map and tabulated grain P concentration.



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